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**Heterogeneity in sex differences in the metabolic syndrome in Dutch white,  
Surinamese African and South Asian populations**

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**Running head:** Sexual heterogeneity in the metabolic syndrome • *C. Agyemang et al.*

## Abstract

**Aim** To determine whether sex differences in the prevalence of the metabolic syndrome and its components differ among different ethnic groups.

**Methods** A random sample of non-institutionalized adults aged 35–60 years in Amsterdam, the Netherlands (white Dutch men  $n = 242$ , women  $n = 244$ ; African-Surinamese men  $n = 193$ , women  $n = 399$ , Hindustani-Surinamese men  $n = 149$ , women  $n = 186$ ). The metabolic syndrome was defined according to the International Diabetes Federation criteria.

**Results** In all ethnic groups, the prevalence of central obesity and reduced HDL cholesterol were higher in women than in men, but the prevalence of elevated blood pressure, fasting glucose and triglycerides were lower in women than in men. However, the magnitude of the differences varied. The sex differences in the prevalence of central obesity and reduced HDL cholesterol were particularly larger in ethnic minority groups, especially in African-Surinamese than in white Dutch. After adjustment for education, smoking, alcohol intake and physical activity, the prevalence of the metabolic syndrome was lower in white Dutch women than in white Dutch men (adjusted prevalence ratio 0.70, 95% CI 0.52–0.94). By contrast, the prevalence of the metabolic syndrome was higher in African-Surinamese women than in African-Surinamese men (adjusted prevalence ratio 1.56, 95% CI 1.12–2.18). Among Hindustani-Surinamese, men and women had a similar prevalence of the metabolic syndrome (adjusted prevalence ratio 1.00, 95% CI 0.76–1.31).

**Conclusions** Our findings suggest different patterns in sex differences in the metabolic syndrome among the ethnic groups. The relatively high prevalence of central obesity in African-Surinamese women may underlie their higher prevalence of the metabolic syndrome. Strategies to improve metabolic profiles among African-Surinamese and white Dutch people need to take sex differences into account.

**Keywords** ethnicity, gender, metabolic syndrome

## Introduction

The metabolic syndrome is an important risk factor for the development of Type 2 diabetes [1–5]. The metabolic syndrome and its components have been observed in many settings and the influence of sex on its prevalence varies between populations in different settings [6]. In Europe, the earlier studies found the metabolic syndrome to be more prevalent in men than in women [6–9]. By contrast, in the USA, the prevalence of the metabolic syndrome was found to be similar between white American men and women, whereas higher prevalence rates were found among African-American and Mexican-American women than in African-American and Mexican-American men [10]. Recent epidemiological data indicate that the prevalence of the metabolic syndrome is on the increase and this increase has been steeper in women than in men during the last decade [11–12]. Recent studies in some European countries also indicate that the sex gap in the prevalence of the metabolic syndrome may be closing [13–15].

The increasing prevalence of the metabolic syndrome in women is thought to be largely attributable to the steady rise in obesity in women [12], and the prevalence of obesity is particularly high among ethnic minority women living in Europe and North America [16–18]. Evidence also indicates that the increasing prevalence of obesity has been steeper in ethnic minority women than in their white counterparts in the last decade [16].

In Europe, only a few studies, mainly in the UK, have assessed ethnic differences in the prevalence of the metabolic syndrome [9,19]. Studies on sex difference in metabolic syndrome prevalence among different ethnic groups are rare in Europe. It is also unknown whether the prevalence of the metabolic syndrome and its components differ by sex in different ethnic groups in different European countries. The aim of this paper was therefore to determine whether sex differences in the prevalence of the metabolic syndrome and its components vary among different ethnic groups. We hypothesized that the prevalence of the metabolic syndrome would be higher in ethnic minority women than in men.

## **Patients and methods**

### **Study population**

The SUNSET study was a cross-sectional study that aimed to assess the cardiovascular risk factors among three ethnic groups in the Netherlands: African-Surinamese, Hindustani-Surinamese and white Dutch people. Details of the study methods have been published elsewhere [20–21]. Briefly, the study was based on a sample of 35- to 60-year-olds in South Amsterdam, the Netherlands. Approximately 2975 individuals were randomly selected from the Amsterdam population register. People in these samples were approached for an oral interview between 2001 and 2003. The overall response rate was 60% among the Surinamese and 60% among the white Dutch people. Those who responded to the oral interview were invited for medical examination. The subsequent response rate was 84% among the Surinamese and 90% among the white Dutch. All participants signed a consent form. The Medical Ethical Committee of the Amsterdam Academic Medical Centre approved the study protocols.

### **Measurements**

Ethnic groups were classified according to the self-reported ethnic origin [20]. Waist circumference was measured to the nearest centimetre at midway between the lower rib margin and the iliac crest with an ordinary tape measure. Blood pressure was measured in the morning with a validated oscillometric automated digital blood pressure device (Omron M-4; XXXXX, XXXX, Japan) by trained staff in the Academic Medical Centre. Using appropriate cuff sizes, two readings were taken on the right arm in a seated position after the subject had emptied their bladder and had been seated for at least 5 min. The mean of the two readings was used in the analyses. Fasting venous blood was taken for the measurement of fasting glucose (HK/glucose-6-P dehydrogenase test; Roche Diagnostics, XXXXX, XXXXX), HDL cholesterol (homogenous enzymatic colorimetric test; Roche Diagnostics) and triglycerides (GPO-PAP enzymatic test; Roche Diagnostics). Information on demographics, education,

physical activity, alcohol consumption and medical history was obtained during the participant's interview. The metabolic syndrome was defined according to the recent International Diabetes Federation criteria [23–24].

### **Data analysis**

Baseline data were expressed as means or percentages. Sex difference in the metabolic syndrome and its components were assessed in each ethnic group by means of Poisson regression analyses with robust variance [25]. Statistical analyses were performed using Stata version 11.0 (StataCorp, College Station, TX, USA).

### **Results**

Of the 1444 who attended the physical examination, 1413 people had complete data on the metabolic syndrome. The prevalence of alcohol consumption was lower in women than in men in all ethnic groups (Table 1). The mean BMI and the prevalence of smoking were higher in African-Surinamese and Hindustani-Surinamese women than in their male counterparts. African-Surinamese women played sports less often than African-Surinamese men.

In all ethnic groups, women had a higher prevalence of central obesity, but had lower prevalence of elevated blood pressure, fasting glucose and triglyceride levels than men, although not all the differences were statistically significant. African-Surinamese women had a higher prevalence of reduced HDL cholesterol than African-Surinamese men. The magnitude of the differences varied between the ethnic groups. After adjustment for age, educational level, smoking, alcohol consumption, playing sports, the adjusted prevalence ratio of central obesity was 1.18 (95% CI 1.01–1.36) in white Dutch women compared with white Dutch men; adjusted prevalence ratio 2.29 (95% CI 1.85–2.84) in African-Surinamese women compared with African-Surinamese women; and adjusted prevalence ratio 1.26 (95% CI 1.09–1.45) in Hindustani women compared with Hindustani-Surinamese men, respectively (Fig. 1). The prevalence of the metabolic syndrome was lower in white Dutch women than in white

Dutch men (adjusted prevalence ratio 0.70, 95% CI 0.52–0.94). By contrast, African-Surinamese women had a higher prevalence of the metabolic syndrome than African-Surinamese men (adjusted prevalence ratio 1.56, 95% CI 1.12–2.18) while Hindustani men and women had a similar prevalence of the metabolic syndrome (adjusted prevalence ratio 1.00, 95% CI 0.76–1.31). There was evidence of sex–ethnicity multiplicative interaction for the metabolic syndrome ( $P < 0.01$ ).

## Discussion

Studies on sex differences in the prevalence of the metabolic syndrome and its components among different ethnic groups are rare in Europe [9]. Our current findings indicate different sex patterns in the prevalence of the metabolic syndrome among ethnic groups.

Consistent with several earlier studies in Europe [6–9], we found a lower prevalence of the metabolic syndrome in white Dutch women than in white Dutch men. By contrast, African-Surinamese women had a higher prevalence of the metabolic syndrome than African-Surinamese men. Hindustani-Surinamese men and women had a similar prevalence of the metabolic syndrome. The comparatively high prevalence of the metabolic syndrome in African-Surinamese and the lack of difference between Hindustani men and women were largely attributable to the high prevalence of central obesity and, to a lesser extent, reduced HDL cholesterol in women. The percentage of sex differences in central obesity, for example, were 49 and 22% higher in African-Surinamese and Hindustani-Surinamese women than in their respective male counterparts, compared with 12% difference in the white Dutch group. Despite the higher prevalence of central obesity in ethnic minority women, the prevalence of Type 2 diabetes did not vary by sex. Presumably, this might be an effect of the ethnicity/sex specific cut-points.

The higher prevalence of the metabolic syndrome in African-Surinamese women in our current study is consistent with the finding in the USA [10,18]. In the National Health and Nutrition Examination Survey (NHANES) study, the prevalence of the metabolic syndrome was higher in African-American women than in African-American men [10,18]. In that study, central obesity was an important factor for the higher prevalence of the metabolic syndrome in African-American women compared with African-American men in the USA. The higher prevalence of central obesity among African-descent women may contribute to their observed high prevalence of the metabolic syndrome in both Europe and the USA.

Our current findings among Hindustani-Surinamese populations, however, contrast the observations made on South Asian populations in the UK [9]. In the study of Unwin *et al.* study, South Asian men had a higher prevalence of the metabolic syndrome than South Asian women (46 vs. 38%) [9]. The explanations for the different patterns of the metabolic syndrome among the South Asian populations in the UK and the Netherlands are unclear. However, the magnitudes of the sex differences in the prevalence of the metabolic syndrome components such as central obesity and reduced HDL cholesterol were smaller in the UK than the Netherlands, which may contribute to observed differences between the two countries.

Prevention of obesity is the main therapeutic goal in patients with the metabolic syndrome [29]. The importance of weight management in preventing progression of metabolic syndrome components has been demonstrated by the Coronary Artery Risk Development in Young Adults (CARDIA) study [30]. Weight reduction is optimally achieved with a multi-modality approach, including physical activity and diet [30]. Given the beneficial effects of physical activity on weight reduction, promotion of physical activity may help to bridge the gender gap in the metabolic syndrome, particularly in ethnic minority women in whom obesity is highly prevalent but physical activity levels are low.



The main strength of our study is the use of the current International Diabetes Federation definition, which incorporates ethnicity-specific cut-off points for waist circumferences [23–24]. Our study also has limitations, including the cross-sectional nature of the study design and lack of data on other pertinent variables such as diet. Furthermore, some of the data such as playing sports and smoking were based on self-report, which may be subject to reporting bias. Finally, bias could have resulted from a differential selective response rate [21].

In conclusion, our findings indicate different patterns in sex differences in prevalence of the metabolic syndrome among the ethnic groups. The relatively high prevalence of central obesity in African-Surinamese women may contribute to their high prevalence of the metabolic syndrome. Strategies to improve metabolic profiles among African-Surinamese and white Dutch people need to take gender differences into account.

### **Competing interests**

Nothing to declare.

### **Acknowledgement**

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**Table 1** Characteristics of the study population stratified by gender in each ethnic group

	White Dutch			African-Surinamese			Hindustani -Surinamese		
	Women (n = 244)	Men (n = 242)	Difference (95% CI)	Women (n = 399)	Men (n = 193)	Difference (95% CI)	Women (n = 186)	Men (n = 149)	Difference (95% CI)
Age (years)	47.6 (7.0)	48.1 (6.6)	-0.45 (-1.67 to 0.76)	43.6 (5.8)	43.9 (6.2)	-0.42 (- 1.46 to 0.62)	45.0 (6.7)	44.4 (6.7)	0.62 (-0.82 to 2.07)
BMI (kg/m <sup>2</sup> )	26.0 (5.2)	26.3 (4.4)	-0.30 (-1.15 to 0.56)	29.5 (5.8)	26.1 (4.7)	3.39 (2.53 to 4.26)	27.7 (5.1)	26.2 (5.4)	1.52 (0.37 to 2.66)
Waist circumference (cm)	87.7 (14.4)	96.0 (12.5)	-8.27 (- 10.67 to - 5.87)	95.0 (15.2)	90.5 (12.5)	4.51 (2.20 to 6.83)	93.9 (12.3)	95.0 (12.6)	-1.10 (- 3.99 to 1.42)
LDL cholesterol (mmol/l)	3.49 (0.9)	3.75 (0.9)	-0.26 (-0.42 to -0.09)	3.15 (0.09)	3.26 (0.09)	-0.11 (- 0.27 to 0.06)	3.41 (0.09)	3.44 (0.09)	-0.03 (- 0.23 to 0.17)
Education to high* %	74 (30.6)	98 (40.2)	-9.6 (-18.0 to 1.1)	79 (20.0)	31 (16.1)	3.9 (-0.3 to 10.4)	14 (10.2)	19 (9.4)	0.8 (-7.0 to 7.2)
Current smoking, yes %	103 (43.3)	97 (42.2)	1.1 (-7.9 to 10.0)	96 (28.2)	96 (55.5)	-36.1 to - 18.6)	37 (21.4)	78 (53.1)	-42.2 to - 22.0)
Play sport, yes %	104 (43.0)	98 (40.2)	2.8 (-6.0 to 11.6)	102 (25.6)	73 (37.8)	-12.2 to - 20.4 to - 4.2)	48 (25.8)	48 (32.2)	-6.4 (-16.4 to 3.4)
Alcohol consumption, yes %	184 (78.6)	225 (94.9)	-16.3 (-22.3 to -10.3)	174 (53.1)	144 (80.5)	-35.4 to - 19.3)	52 (32.1)	89 (61.8)	-40.3 to - 18.7)
Hypertension† %	47 (19.4)	88 (36.1)	-16.7 (-24.5 to -8.8)	149 (37.3)	87 (45.1)	-7.8 (-16.2 to 0.1)	64 (34.4)	61 (40.9)	-6.5 (-17.0 to 4.0)
Diabetes mellitus‡ %	14 (5.8)	19 (7.8)	-2.0 (-6.5 to 2.5)	51 (12.8)	23 (11.9)	0.9 (-4.8 to 6.5)	48 (25.8)	37 (24.8)	1.0 (-8.5 to 10.4)
Metabolic syndrome and components									
Elevated waist circumference§ %	158 (65.3)	130 (53.3)	12.0 (3.0 to 20.7)	334 (83.7)	66 (34.2)	49.5 (41.9 to 57.2)	163 (87.6)	98 (65.8)	21.8 (12.8 to 30.9)
Elevated triglyceride** %	40 (16.5)	73 (29.9)	-13.4 (-20.8 to -6.0)	38 (9.5)	25 (13.0)	-3.5 (-9.0 to 2.1)	21.5 (21.5)	50 (33.6)	-12.1 (- 21.7 to - 2.4)
Reduced HDL cholesterol†† %	52 (21.5)	44 (18.0)	3.5 (-3.7 to 10.6)	134 (33.6)	31 (16.1)	17.5 (10.5 to 24.5)	92 (49.5)	59 (39.6)	9.9 (-1.0 to 20.6)
Elevated blood pressure¶ %	70 (28.9)	123 (50.4)	-21.5 (-30.0 to -13.0)	186 (46.6)	117 (60.6)	-14.0 to - 22.5 to - 05.6)	95 (51.1)	78 (52.4)	-1.3 (-12.1 to 9.6)
Elevated fasting glucose‡‡ %	59 (24.4)	96 (39.4)	-15.0 (-23.2 to -6.8)	138 (34.6)	75 (38.9)	-4.3 (-12.6 to 4.1)	88 (47.3)	91 (61.1)	-13.8 (- 24.5 to - 3.1)
Metabolic syndrome %	65 (26.9)	81 (33.2)	-6.3 (-14.5 to 1.8)	146 (36.6)	40 (20.7)	15.9 (8.4 to 23.3)	95 (51.1)	77 (51.7)	-0.6 (-11.5 to 10.2)

Values are mean (SD) or number (percentages) and percentage or mean difference with corresponding 95% CIs.

\*Vocational school and above, i.e. 13 years of education (high).

†Systolic blood pressure  $\geq$  140 mmHg or diastolic blood pressure  $\geq$  90 mmHg or being on anti-hypertensive therapy.

‡Fasting glucose  $\geq$  7.0 mmol/l and/or self-reported Type 2 diabetes.

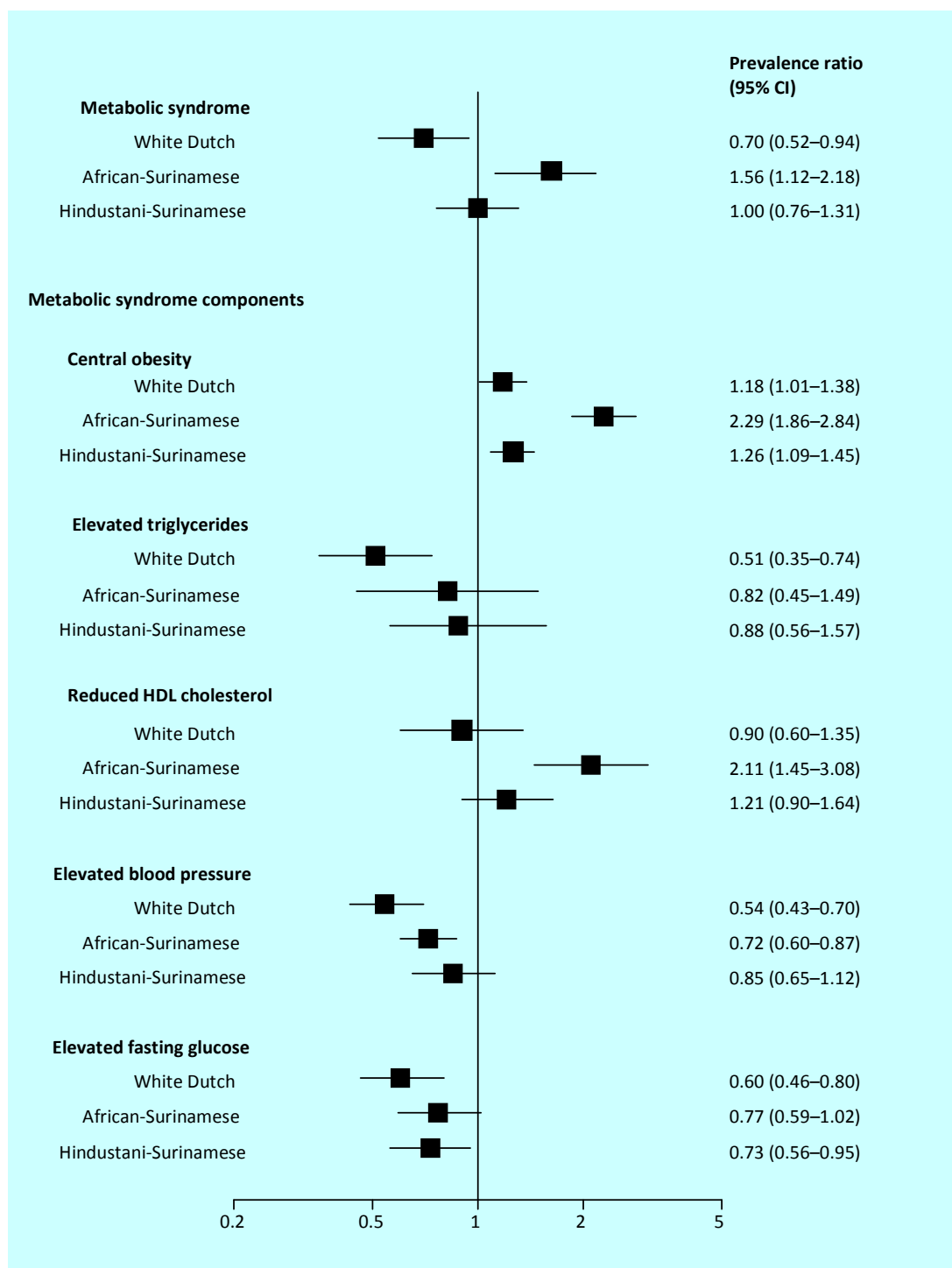
§Waist circumference  $\geq$  94 cm in Dutch and African-Surinamese men and  $\geq$  90 cm in Hindustani men; and 80 cm in women in all ethnic groups.

¶Systolic blood pressure  $\geq$  130 mmHg and/or diastolic blood pressure  $\geq$  85 mmHg or anti-hypertensive drug treatment.

\*\*Triglycerides  $\geq$  1.7 mmol/l or drug treatment for elevated triglycerides.

††HDL cholesterol  $\geq$  1.0 mmol/l in males and  $<$  1.3 mmol/l in women or drug treatment for reduced HDL cholesterol.

‡‡Fasting glucose  $>$  5.5 mmol/l or drug treatment of increased glucose.



**Figure 1** Adjusted prevalence ratios of the metabolic syndrome and its components by sex in each ethnic group. Men are the reference category in each ethnic group. Prevalence ratios were adjusted for age, educational level, smoking, alcohol consumption and physical activity.